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Effects of instruction supported by web 2.0 tools on prospective teachers' biotechnology literacy☆

Esra Açikgül Firat[a,*], Mustafa Serdar Köksal[b]

[a] Adiyaman University, Education Faculty, Department of Science Education, Adiyaman, Turkey
[b] Hacettepe University, Faculty of Education, Department of Special Education, Ankara, Turkey

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ABSTRACT

The purpose of this study is to determine the effect of instruction supported by Web 2.0 tools on prospective science teachers' biotechnology literacy. The study was conducted by using experimental pretest-posttest control group design. The sample was composed of 60 prospective science teachers. These prospective science teachers were randomly assigned to experimental and control groups in equal numbers. "Biotechnology Literacy Test" and open-ended questions were used to collect the data. The scientific literacy classification of Bybee (1997) was used as a framework for determining the biotechnology literacy of prospective science teachers. Therefore, biotechnology literacy of the prospective science teachers was examined based on nominal, functional, conceptual, multidimensional literacy levels. According to the results, there was a statistically significant difference between pretest and posttest scores of the experimental group at multidimensional literacy in favor of the posttest. However, there was no significant difference between the control group's pretest and posttest results. When compared groups on the pretest and posttest scores, statistically significant differences were identified at nominal, functional and multi-dimensional literacy levels in post-tests. Moreover, the experimental process influenced the experimental group's decision-making process in their daily life problems. Suggestions were presented under the results obtained from the research.

1. Introduction

Internet techonologies is used widely in our daily lives. The twenty-first century is perceived as an era of transformation and reform, due to the rapid progression of digital technologies and changes in which communication and information are accessed (Barak, 2017). Now, we can connect to the internet whenever and wherever we want, and we can instantly gain access to information. The internet first came into our lives via web sites, and this web technology was called Web 1.0. This first stage of Web-focused solely on providing information (Akçay, 2009; Albion, 2008; Rosen & Nelson, 2008; Stevenson & Liu, 2010), and the users were only able to gather information through navigation, scanning and downloading in these environments (Thomas & Li, 2008). As this one-way information flow on Web sites became inadequate, new searches were made, and web technologies have changed thereafter. Web 2.0 tools supported by resources, services, and environments emerged due to the rebirth of the Internet, and a shift towards new technologies providing user engagement has been experienced (Collis & Moonen, 2008). Due to this paradigm shift, for

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* Corresponding author.
E-mail address: eacikgul@adiyaman.edu.tr (E. Açikgül Firat).

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not only website owners but the users have played a role in web content design and creation (Anderson, 2012). Therefore, Web 2.0 is the next phase of internet use. While Web 1.0 has a one-way flow of information, Web 2.0 brings dynamism to these environments. Because it provides user participation in presenting and creating information (Rosen & Nelson, 2008). There have been improvements in communication and sharing information with this change (Harper, 2012).

In 2004, Web 2.0 was brought to the agenda at a brainstorming session between MediaLive International and American publisher Tim O'Reilly who has specialized in publications on the emerging technologies and networks (Albion, 2008; Magnuson, 2012; O'reilly, 2007; Pieri & Diamantini, 2014; Rives, 2009). Web 2.0 differs from Web 1.0 in terms of writing capability. Therefore, Web 2.0 is defined as "read/write" by some researchers (Albion, 2008; Rosen & Nelson, 2008). The definition of the Web 2.0 concept is highly controversial, so the definitions are not similar. It is an environment where individuals can create and modify content, rearrange content according to their purposes, and it leads individuals to use of collective intelligence. User-generated content and social media platforms, such as blogs, social networking, etc. became the symbols of the Web 2.0 environment (Holland, 2019). With Web 2.0, individuals no longer use the Web for specific actions, such as access to content; use social interaction and collective knowledge to create knowledge (Alajmi, 2011). Now users create new content and share it with large groups of people by Web 2.0 tools or change existent content by the help of more current information. This environment focuses on connection, collaboration, social interaction, sharing, collating existing content and development (Buffington, 2008; Drexler, Baralt, & Dawson, 2008; Grosseck, 2009; Huang, Yang, & Tsai, 2009; Rosen & Nelson, 2008; Thomas & Li, 2008). Therefore, in Web 2.0, users can use the web as an environment to create content, change it for other purposes, and shared content (Franklin ve Harmelen, 2007). Thus, in the Web 2.0 environment, users are not only consumers but also play a role as producers. In this respect, Web 2.0 can be associated with a platform with a performance area, which is similar to a theater stage (Tu, Blocher, & Roberts, 2008).

According to Web 2.0 definitions, when the features that are included in these technologies are considered, the first thing to note is that the users are in the role of producer. Because Web 2.0 tools include tools that provide high user participation, are updated frequently, and maintain capacity for collective information sharing (Fahser-Herro, 2010). In these tools, users create their own applications and personalize applications to share and modify (Fahser-Herro & Steinkuehler, 2009). Therefore, while the users have the advantage of creating content beyond content consumption, information is liberated from corporate control (Kamel Boulos & Wheeler, 2007).

Web 2.0 technologies include a group of technological tools, which are deeply related to terms such as blogs, wikis, podcasts, RSS feeds and so on provide social connectivity to the Web (Anderson, 2007). As these new generations of web-based software tools continue to emerge, some educators also use these new tools in teaching activities (Farmer, 2009). Web 2.0 tools allow content sharing, collaboration, and communication among users. Also, the easier to use of Web 2.0 tools allows web users to develop content even with less experience in information communication technologies (Pieri & Diamantini, 2014). Therefore, educators have also noticed the beneficial properties of these tools. It has also been noticed that these tools are compatible with student-centered and interactive approaches advocated by contemporary educational leaders (Bower, Hedberg, & Kuswara, 2009). Thus, it has become inevitable for Web 2.0 tools to be included in the education process. Social constructivist approaches can use Web 2.0 as an intermediary in the mechanisms between pupils, students-teachers and especially students working in different places at different times (Franklin & Harmelen, 2007). Students can easily communicate with their teachers and peers in Web 2.0 environments. This feature enables users to interact with information more effectively and collaborate in various educational formats (Rhoads, Berdan, & Toven-Lindsey, 2013).

1.1. Web 2.0 as an educational intervention

Integrating Web 2.0 tools into the education provides a great potential for teachers and students in enhancing and improving the quality of teaching and learning, and helps users interact with information more actively and collaboratively in various educational formats (Rhoads et al., 2013). Therefore, Web 2.0 tools have the potential to affect educational practices significantly (Buffington, 2008). The learning environment supported by Web 2.0 is based on socio-cultural learning theory, and this socio-cultural approach aims to understand the developmental processes involving social (interpersonal), cultural (community) and habits (activities) at the level of individuals (Tu et al., 2008). For example, a group of students can create a wiki, and this teacher can be guided by the teacher (Franklin & Harmelen, 2007). Wiki also provides transparency and access to video recordings and evaluations of students' recordings and peers' performances (Fraj-Andrés, Lucia-Palacios, & Pérez-López, 2018). Events can also be designed to develop high-level skills such as discussion and reflection in blogs. For example; a blog can be used to present students' reflections on their course reading (Park, 2013). Saurabh and Gautam (2019) have emphasized that YouTube, one of the most popular Web 2.0 websites, is an extensive resource for educational content and it has changed the way people learn.

There are many studies on the various uses of Web 2.0 tools for educational purposes. Bower, Hedberg, and Kuswara (2010) reported how potential Web 2.0 technologies could help cognitive and collaborative learning in learning to provide pedagogical and contextual needs. Magnuson (2012) also stated how these tools could help students to understand the concepts of knowledge evaluation, knowledge organization, and information literacy. The software functionality of Web 2.0 helps to support individual learning by providing different modes of presentation that address multiple senses (London & Hall, 2011). Thus these networks can contribute to students learning with different learning styles by providing services like text, audio, video and so on. Fahser-Herro and Steinkuehler (2009) emphasized that Web 2.0 significantly contributes to literacy in schools and thus changes reading, writing, and evaluation.

Moreover, there are studies, which suggest how these tools can be used to support learning in higher education (Allen, 2008; Estrada, 2012; Fahser-Herro & Steinkuehler, 2009; Huang, Hood, & Yoo, 2013). The popularity of these networks and their use in education have also shown to have an effect in higher education. For example, because of the popularity of Facebook from social networks among university students, it has become imperative for educators and researchers to understand how this tool can be used as a communication and learning platform (Saini & Abraham, 2019). Estrada (2012), stated that these technologies with its positive effects on cognition, motivation and student participation offer opportunities to increase cooperative learning and development and so they help success in academic environments. Web 2.0 applications support learning and teaching in teacher education through video sharing, collaboration networks, mobile broadband and mobile computing (Huang et al., 2013).

Many people believe that teaching practices will change with these technologies which can be integrated into classes are included in educational environments (Allen, 2008). Teachers who responsible for teaching now need to be familiar with new technologies to have the ability to find and select the technologies that match students' characteristics and learning styles, and not to be behind their students. As the use of these tools in society has increased, some educators have started to implement these tools in classes, but there are broader expectations of practice in schools (Albion, 2008). Moreover, these tools can be used in a variety of ways to contribute to learning, as well as providing a communication environment for teachers to share and share information (Conole, 2010). Teachers are seen to use some Web 2.0 tools in their classrooms, but there are also opportunities to create new tools specifically for educational use and to make such tools more suitable for education (Albion, 2008). Teachers should be familiar with Web 2.0 tools to understand these opportunities and begin to use them in their classes. Considering these requirements the teacher education programs have also taken into account the impacts of Web 2.0 as in other areas of higher education (Albion, 2008). Furthermore, academic teaching can be altered to educate the students with Web 2.0 technologies by providing a different pedagogical approach through cooperative learning and social constructivism (Newland & Byles, 2014).

1.2. Biotechnology literacy

Web 2.0 can be integrated at all levels of primary and secondary education as well as higher education and academic community. As the methods of access to information have changed, innovations have come to the fore in higher education, and these technologies have taken place in teaching activities. The most important aim of universities is to create independent individuals (Franklin & Harmelen, 2007). These independent individuals design their learning objectives, develop plans and strategies to achieve these goals, work on their own or with others to develop their goals, reflect these goals and activities in their learning process and have the ability to control their outputs (Franklin & Harmelen, 2007). All these features will be possible if individuals are educated as scientifically literate. Developing scientifically literate person who knows the meaning nature of science and technology in a social context is a national focus of science education (Gardner & Jones, 2011).

Several studies have been carried out in this area to educate individuals to reach high levels of scientific literacy, and this concept has been defined and categorized in various forms (Bybee & McCrae, 2011; Dani, 2009; Harlen, 2001; Hurd, 1998; Laugksch, 2000; NRC, 1996; Sadler & Zeidler, 2009; Schwartz, Ben-Zvi, & Hofstein, 2006). According to Bybee (1997), scientific literacy is a metaphor expressing the equal opportunities for all students and the norms/standards for science education programs, methods, and evaluations, representing the continuity of understandings and abilities, including both science and technology along with various dimensions and also addressing to the purpose of science education. With the increasing emphasis on scientific literacy, researchers in science education have begun to strive to promote scientific literacy backed by the ability of individuals to make conscious decisions (Fonseca, Costa, Lencastre, & Tavares, 2012). Socio-scientific issues differ from the other issues due to their open-ended, unstructured and debatable nature. These issues consist of complex problems, which we encounter in daily life.

Biotechnology is also one of the socio-scientific issues we have encountered in almost every field. The reason for the rapid growth of biotechnology over the past 5–10 years is due to its potential to solve global problems (Bruschi et al., 2011). The Hungarian engineer Karl Ereky first used the term ‘biotechnology’ in 1917. Ereky noted that biotechnology is the process in which products are produced from the materials used by living organisms (Lamanauskas & Makarskaitė-Petkevičienė, 2008). We encounter this science field in many sectors such as medicine, health, food, clothing, agriculture, and industry.

The ability of individuals to make conscious decisions about themselves and for future generations depends on their awareness of the risks and benefits of biotechnology (Sohan, Waliczek, & Briers, 2002). This awareness will be possible with biotechnology literacy as a type of scientific literacy. Therefore it is important to be biotechnologically literate for individuals. Biotechnology literacy requires a scientific literacy that is a great need for students, teachers, and citizens, and thus scientifically literate individuals can realize how biotechnology affects their lives and societies (Chabalengula, Mumbai & Chitiyo, 2011). In this way, students with biotechnology literacy get information about all aspects of biotechnological development and can make conscious decisions about the relevant topics. They can also actively participate in different aspects of modern life by understanding the biotechnology processes and the related news in the media (Harlen, 2001).

Scientific literacy includes scientific knowledge, but it also extends to the practice of this knowledge, such as deciding about personal and social situations with scientific and non-scientific components (Lederman, Antink, & Bartos, 2014). It is important to have the ability to decide in this regard as we must make a selection that relates to the field of biotechnology even when shopping at a store. The aim of teaching biotechnology literacy is to make the uninformed populations capable of deciding on the reliability of products (Golick, Peterson & Highley, 2009). Moreover, Roberts (2007, pp. 729–780) mentioned that teaching scientific literacy purposes to give experience on the process of personal decision making about socio-scientific issues related to real life. In addition, one objective of teaching the socio-scientific issues identified by Ratcliffe and Grace (2003) is to make students understand the nature of personal and social decision-making process. Therefore, the ability to decide is deemed important as demonstrating biotechnology literacy. Because individuals have to assess information integrity, observe risks and benefits, ask questions and evaluate them before making decisions (Dawson & Venville, 2009).

Effective biotechnology teaching is required to increase biotechnology literacy. A problem encountered in biotechnology education is the insufficiency in using the teaching methods and materials (Darçın, 2007). Therefore, new methods and materials are needed to be integrated into the teaching process. The fact that biotechnology is a socio-scientific subject facilitates the integration of technology into the teaching process as a new method. Science and technology expeditiously progress in biotechnology so they cannot be followed. Thus these developments cannot be reflected in our teaching programs at the same speed, the scope of the subjects becomes insufficient, and the biotechnology teaching remains at a theoretical and superficial level (Kaya, 2009).

1.3. The rationale of the study

The increasing use of Web 2.0 technologies in people's lives and that Web 2.0 technologies have become a useful platform for following recent studies and news may provide a solution to the problems in biotechnology teaching. Because, today, the internet is an increasingly popular forum for spreading biotechnological information (White, 1999). This collaborative nature of Web 2.0 technologies facilitating communication supports biotechnology literacy. For example; social media and search engines have the potential to facilitate the exchange of information between healthcare professionals and patients, and also simplify the evaluation of new treatments that accelerate the discovery of new and undetected diseases (Costa, 2013). There are groups related to biotechnology applications in social media, and new studies are shared in these groups. In addition, there is quite a large variety of biotechnology web sites, many of which are related to companies, and others are generally designed by universities or research centers (White, 1999). YouTube also contains videos about biotechnology processes and procedures. As a result, Web 2.0 technologies can be deemed as tools to support the biotechnology literacy that offers environments in which individuals can access information about biotechnology and current developments, comprehend the nature of biotechnology, follow and understand biotechnological processes, identify the positive and negative aspects of biotechnology and develop positive attitudes about biotechnology. Because of these features, teachers can also benefit from these technologies during the teaching process.

The nature of the content and the proposed strategies can lead to limited participation of teachers in biotechnology teaching (Fonseca et al., 2012). By integrating Web 2.0 technologies into biotechnology teaching, teachers can get opportunities to find resources and materials. The dynamic structure of the biotechnology field facilitates the integration of rapidly developing technologies into the teaching processes and offers new opportunities for learning environments. Web 2.0 technologies can be developed logically with ease of use and providing a high level of collaboration and interaction, makes it easier to use in teaching (Quadri, 2014). Furthermore, science teachers who have a limited understanding of socio-scientific issues are often uncomfortable in teaching ethics and economics (Moses, 2003). Through these technologies, teachers can reach the environments where they learn about the risks, ethical concerns and economy of the biotechnology. For example; all experiences are shared in teacher networks generally using Web 2.0 tools such as blogs, wikis and teacher publications (Albion, 2008). Teachers must be familiar with these technologies and should not avoid using them, to benefit from these technologies during the process of biotechnology teaching, The pre-service period has an important role for teachers to learn the opportunities offered by Web 2.0 tools in teaching biotechnology, and use these tools in their teaching experiences to teach biotechnology. Because, teachers are expected to be technologically literate by incorporating technological tools into their teaching practices (Pamuk ve Peker, 2009). Moreover, the most obvious stage of teachers' participation in technology is the pre-service phase (Odabaşı, 2007), therefore, as in other areas of higher education, teacher training activities have taken Web 2.0 effects into account (Albion, 2008). Therefore, it is important for science teachers to take advantage of the opportunities, which these technologies offer biotechnology courses, during the pre-service period. Thus, from this viewpoint, this research aims to determine the effect of biotechnology teaching supported by Web 2.0 technologies on biotechnology literacy of prospective science teachers. This present study used the scientific literacy classification of Bybee (1997) as a framework for determining the biotechnology literacy of prospective teachers. Using Bybee's scientific literacy classification is important because it has easier adaptability to teaching objectives compared with other classifications. Therefore, biotechnology literacy of the prospective teachers was examined based on nominal, functional, conceptual, multidimensional literacy levels. In the nominal literacy, students know what the scientific concept, but have misconceptions; in the functional literacy, students have limited understanding about a concept; in the conceptual scientific literacy, students have understanding regarding procedural skills and design process, and multidimensional scientific literacy covers competencies regarding philosophical, historical, and the social basics of science and technology (Schwartz et al., 2006).

In addition, the development of the prospective teachers in terms of biotechnology literacy was followed throughout the research process and during the study by giving them open-ended decision making questions including biotechnological issues. Therefore, associating the study with daily life is important in terms of its functionality. Because every day individuals face with socio-scientific issues such as using mobile phones, eating genetically modified foods, or recycling of household waste (Dawson & Venville, 2009). In this context, biotechnologically literates should use science and make conscious decisions in situations that they encounter in daily life. Thus, examination of the decisions made on biotechnology issues by prospective teachers can be a sign of the functioning of the study.

From this viewpoint answers were sought for the following sub-problems:

1. In terms of the nominal, functional, procedural, multidimensional literacy levels aspects of biotechnology literacy.
   a. Is there a statistically significant difference between the pre-test scores and post-test scores of the experimental group?
   b. Is there a statistically significant difference between the pre-test scores and post-test scores of the control group?
   c. Is there a statistically significant difference in pretest scores of the experimental and control groups?
   d. Is there a statistically significant difference in posttest scores of the experimental and control groups?
2. How is the change in the nature of prospective teachers' decisions regarding biotechnology issues?

2. Method

2.1. Model of the research

The experimental research method was used in this study. In such studies; researchers examine the effect of at least one independent variable on one or more dependent variables and manipulate independent variables (Cohen, Manion, & Morrison, 2000; Fraenkel, Wallen, & Hyun, 2012; Miller, Strang, & Miller, 2010). In this study, pretest-posttest control group designs were used from true experimental designs. In the present study, the participants were randomly assigned to the experimental and control groups.

2.2. Population and sample

The population of the research consists of the prospective science teachers who are studying at universities in Turkey; the sample is composed of 60 prospective science teachers who study in the junior grade in a small scale university and were selected by the convenient sampling method. This is because only junior-grade students take the “Genetics and Biotechnology” course in which application is performed. The students were randomly assigned to the experimental and control groups equally. The demographic information of the prospective teachers in the groups is presented in Table 1.

Table 1
General characteristics of a sample.

				Female	Male		
Gender		Control G.	N	21	9		
			%	70	30		
		Experimental G.	N	26	4		
			%	86,7	13,3		
Internet usage statistics				**Less than 1 h**	**1–2 h**	**3-4 h**	**Over 4 h**
		Control G.	N	6	8	15	1
			%	20	26,7	50	3,3
		Experimental G.	N	6	14	5	5
			%	20	46,7	16,7	16,6
				Never	**Rarely**	**Often**	**Always**
Frequency of use	Blogs	Control G.	N	10	14	4	–
			%	33,3	46,7	13,3	
		Experimental G.	N	10	16	3	–
			%	33,3	53,3	10	
	Wikipedia	Control G.	N	4	10	12	3
			%	13,3	33,3	40	10
		Experimental G.	N	2	14	9	5
			%	6,7	46,7	30	16,7
	Social Network	Control G.	N	–	2	12	15
			%		6,7	40	50
		Experimental G.	N	–	6	10	14
			%		20	33,3	46,7
	Instant messaging	Control G.	N	8	5	6	8
			%	26,7	16,7	20	26,7
		Experimental G.	N	5	6	8	9
			%	16,7	20	26,7	30
	Video sharing	Control G.	N	2	6	11	9
			%	6,7	20	36,7	30
		Experimental G.	N	1	7	12	9
			%	3,3	23,3	40	30

2.3. Data collection tools

In the study, the data were collected through the “Biotechnology Literacy Test” developed by the researchers (Açıkgül Fırat & Köksal, 2019). “Biotechnology Literacy Test” is a measurement tool consisting of 25 multiple choice questions with five options. For this purpose, 42 items were prepared by considering Bybee's scientific literacy dimensions (nominal, functional, procedural, and multidimensional). The items were presented to experts about content validity. As a result of the experts' evaluations, the content validity of the test was confirmed. The draft test was applied to 494 prospective science teachers. Difficulty and discrimination coefficients of items within the test were calculated to provide evidence of construct validity. As a result of the item analyses, it was decided to exclude 13 items. It can be said that the test was difficult and discriminative at a medium level. Finally, a valid and reliable ‘biotechnology literacy test’ consisting of 25 multiple-choice items each with five choices was developed in this research. There are seven items in the nominal literacy dimension, 4 in the functional literacy dimension, 9 in the procedural literacy dimension, and 5 in the multi-dimensional literacy dimension. The KR-20 reliability coefficient was 0.63, and its split-half reliability was 0.60. Rudner and Shafer (2002) stated that the reliability coefficient for tests could be accepted as 0.50 or 0.60. Diederich (1973) also stated that good and useful tests usually have a reliability coefficient of between 0,60 and 0,80.

Moreover, the average difficulty of the test were determined as 0.40, and its average discrimination was determined as 0.41. The highest score that can be taken from the test is 25, and the lowest score is 0. The test consists of four sub-dimensions; nominal, functional, procedural and multidimensional. While the nominal dimension refers to the lowest level, this dimension progressively follows the functional, procedural and multidimensional literacy levels, respectively. Each dimension includes the lower dimensions, simultaneously during the test. For example; the functional literacy dimension also includes questions of the nominal dimension. So the score obtained in multidimensional literacy as the highest dimension is equal to the score obtained from the whole test. Additionally, some of the research data were also collected via weekly open-ended questions asked each week. The open-ended questions were designed to examine the decision-making process in the product selection behaviors of the prospective teachers in their daily lives. These questions asked about the products, which are frequently used in our daily lives (For example, how do you decide which shampoo to buy?).

2.4. Experimental process

The research consists of pilot study and implementation processes. These processes are described in detail below.

2.4.1. Pilot study

The pilot study of the research was made in the Instructional Technologies and Material Design course at the Department of Science Education in Turkey. Web 2.0 technologies were introduced by the researcher, during the three weeks. Also, the sample applications related to the use of these tools in science education were observed. Then prospective teachers used these tools with the researcher for educational purposes. Furthermore, prospective teachers researched how Web 2.0 technologies are used in science teaching about three learning outcomes they chose from the science curriculum. They also presented a report describing the situation of their current research and including recommendations on how to use the Web 2.0 technologies for more effective learning.

2.4.2. Implementation process

The experimental and control groups were included in the study. The implementation was carried out in the “Genetics and Biotechnology” course in the spring semester of the Department of Science Education in Turkey. The experimental and control groups took the course together for six weeks. While the biotechnology education was applied to the experimental group in the Web 2.0 environment, activities involving the same practices were carried out in the school setting in the control group. Thus, the variables that may affect the dependent variable except the independent variable were tried to be controlled by contributing to internal validity. Web 2.0 technologies were used in the experimental group to support biotechnology teaching.; In the experimental process, Facebook from social networks, Google blogger from blogs, Wikipedia, Facebook Messenger for instant messaging were used as Web 2.0 tools. Table 2 summarized how each Web 2.0 tool is implemented in the experimental group and how the same activity is performed in the control group.

After the pilot study, “Biotechnology Literacy Test” was applied to the experimental and control groups at the beginning of the implementation as a pre-test. Before the experimental process, the Facebook group was created, and the prospective teachers in the experimental group became members of the group. All communications in the experimental group were conducted with the group. Also, a blog was opened in Blogger, and prospective teachers and researchers added updated news and videos about biotechnology. In the control group, a discussion environment was created by verbally explaining the news in the blog and/or watching videos. During the implementation process, open-ended decision-making questions were asked at the beginning of the lesson each week, and the answers of the prospective teachers were collected. At the end of the lesson the control group was provided with a discussion about the sharing in the blog or facebook group. In the control group, everything that was done through the Web 2.0 technologies in the experimental group was shared and given an opportunity to discuss. During the research period, 1 h a week was determined for the control group, and the prospective teachers were interviewed. Outside the specified time, prospective teachers could come to the researcher's office. The experimental group has always been able to reach the researcher through the Facebook group and messaging. At the end of the study, “Biotechnology Literacy Test” was applied to the experimental and control groups as a posttest.

2.5. Data analysis

Descriptive statistics were used for the analysis of demographic data in the study and the relevant frequency, and percentage values were presented to determine the characteristics of prospective teachers. As a result of the normality analysis, all the data were found to be normally distributed. Therefore, parametric tests were used. The significance level of 0.05 was taken as a criterion in evaluating test results. However, to reduce the Type I error rate due to the multiple comparisons with the same data, the criterion significance level was determined as equal to $p = 0.003$ ($p = 0.05/16$) after using Bonferroni correction, since 16 tests were performed on the data. Additionally, the effect size values of the statistically significant outcomes of the study were calculated and used to evaluate the results. Cohen d values were calculated for this purpose. The criteria of Cohen (1988) were considered when interpreting the effect size values. According to this classification, $d \leq 0{,}2$ means small effect size, $0{,}2 < d < 0{,}8$ means medium effect size and $d \geq 0{,}8$ means large effect size.

Secondly, the data was collected through open-ended questions to evaluate decision making. The data collected during the 6-week experimental period were scored via a rubric prepared by the researcher for the data analysis and finalized in the line of expert views.

Table 2
The experimental process of the study.

	Tools	Facebook	Blogger	Wikipedia	Facebook Messenger
Experimental group	Intended use	A group was established on Facebook, and the relevant correspondence was provided through this group. Also, the topic related videos from YouTube and information from search engines were found and shared in this group.	The blog was used for discussion in the research. Biotechnology news and videos were shared in the blogs and prospective teachers discussed by commenting on them.	Prospective teachers worked in groups and prepared homework about previously determined biotechnology issues by utilizing from Wikipedia.	Facebook messaging was used to make prospective teachers write reflective daily notes.
Control group		Meetings with the control group were held at the course and office hour (1 h per week). The information on the topics mentioned above was shared, and the relevant videos were watched in the control group as an equivalence of Facebook.	The same biotechnology news and videos were shared with the experimental group were told in the class, and then the control group made in-class discussion on them.	Prospective teachers worked in groups to submit homework on biotechnology topics.	They write reflective daily notes at the end of each lesson.

Table 3
Cramer's v values calculated as expert evaluations.

	N	Cramer's v
1. Week	34	,79
2. Week	42	,64
3. Week	48	,77
4. Week	41	,76
5. Week	38	,60
6. Week	45	,71

The rubric was designed to determine whether prospective teachers use biotechnology knowledge in their decision-making process. The rubric was designed as follows:

1. Makes a decision, but presents no reason.
2. Makes a decision and presents a non-scientific reason.
3. Makes a scientific justification when deciding, but does specify the reason.
4. Makes a scientific justification when deciding, and also explains the reason.

The data were classified as follows after an evaluation according to Rubric:

1. 1–1.75 = does not use biotechnology knowledge when deciding.
2. 1.76–2.50 = uses biotechnology knowledge at a low level when deciding.
3. 2.51–3.25 = uses biotechnology knowledge at a medium level when deciding.
4. 3.26–4.00 = uses biotechnology knowledge at a high level when deciding.

Two experts evaluated the data, and Cramer's v values were calculated to determine the relationship between the scores assigned by these two experts. According to the Cramer's v values, there is a strong correlation between the scores of these two experts in all weeks (Table 3). In the case of different scores, the two experts reached a consensus and gave the required score.

According to the Cramer's v values obtained, it seems that there is a strong correlation between the two experts in all weeks. In the situation where different scores are given, two experts have reached a consensus and given the required score. Examples from the answers of candidate teachers who scored 1, 2, 3 and 4 are presented in the findings. The frequency and percentage values of 3 and 4 also score the students, which are presented graphically.

3. Results

3.1. Results on the first sub-problem

T-tests were used to answer this sub-problem. Dependent *t*-test results are shown in Table 4 to determine whether there is a meaningful difference between the prospective teachers' pre-test scores and the post-test scores.

There is no statistically significant difference was found between the pretest and posttest scores of the experimental and control

Table 4
Paired *t*-test results between pretest-posttest scores of prospective teachers.

	Group		N	$\overline{X}$	Sd	df	t	p	Cohen d
Nominal Literacy	Experimental Group	Pretest	30	4,83	1,51	29	2,50	,018	
		Posttest	30	5,60	1,16				
	Control Group	Pretest	30	4,80	1,37	29	1,33	,194	
		Posttest	30	4,46	1,19				
Functional Literacy	Experimental Group	Pretest	30	6,70	1,96	29	2,00	,055	
		Posttest	30	7,50	1,35				
	Control Group	Pretest	30	6,53	1,56	29	1,50	,142	
		Posttest	30	6,13	1,56				
Procedural Literacy	Experimental Group	Pretest	30	10,56	2,52	29	2670	,012	
		Posttest	30	11,86	1,77				
	Control Group	Pretest	30	10,60	2,07	29	,260	,797	
		Posttest	30	10,50	2,02				
Multi-dimensional Literacy	Experimental Group	Pretest	30	12,76	2,92	29	−5106	,001	1,82
		Posttest	30	15,83	2,27				
	Control Group	Pretest	30	13,13	2,23	29	−1491	,147	
		Posttest	30	13,76	2,28				

Note: 0.003 is used as a significance criterion due to Bonferroni adjustment to decrease Type I error rate.

Table 5
Independent *t*-test results for pre-test scores and post-test scores of prospective teachers.

			N	$\overline{X}$	Sd	df	t	p	Cohen d
Nominal Literacy	Pretest	Control G.	30	4,80	1,37	58	0,08	,92	
		Experimental G.	30	4,83	1,51				
	Posttest	Control G.	30	4,46	1,19	58	3,72	,00	0,97
		Experimental G.	30	5,60	1,16				
Functional Literacy	Pretest	Control G.	30	6,53	1,56	58	,363	,71	
		Experimental G.	30	6,70	1,96				
	Posttest	Control G.	30	6,13	1,56	58	3606	,00	0,84
		Experimental G.	30	7,50	1,35				
Prosedural Literacy	Pretest	Control G.	30	10,60	2,07	58	,05	,95	
		Experimental G.	30	10,56	2,52				
	Posttest	Control G.	30	10,50	2,02	58	,77	,007	
		Experimental G.	30	11,86	1,77				
Multi-dimensional Lİteracy	Pretest	Control G.	30	13,13	2,23	58	,546	,58	
		Experimental G.	30	12,76	2,92				
	Posttest	Control G.	30	13,76	2,28	58	−3510	,00	0,78
		Experimental G.	30	15,83	2,27				

Note: 0.003 is used as a significance criterion due to Bonferroni adjustment to decrease Type I error rate.

groups in nominal, procedural and functional literacy dimensions. However, the results also indicate a statistically significant difference only between pretest scores and posttest scores of the experimental group in the dimension of multi-dimensional literacy. This difference is in favor of the posttest scores. In the control group, the situation is different. Despite an increase in favor of posttest scores, this increase was not statistically significant. Therefore, it can be concluded that the biotechnology teaching conducted with Web 2.0 technologies statistically significantly increased biotechnology literacy of the prospective teachers. Furthermore, the Cohen d value (1,82) indicates that the difference between the pretest and posttest scores of the experimental group is "1,82″ standard deviation. Since this value is 1,82 (1,82 > 0,8), it can be asserted that in practice it has a large effect.

The results of the independent *t*-test, which was conducted to determine whether there is a statistically significant difference comparison of the experimental and control groups for pretest and posttest scores of the prospective teachers, are shown in Table 5.

As seen in Table 5, no statistically significant difference was found between the pretest scores of the control and experimental groups in terms of four literacy dimensions. Therefore, it can be asserted that the groups are equivalent. The posttest results indicate that the mean score of the experimental group in all literacy dimensions is higher than the mean score of the control group. The independent *t*-test results also indicate that the experimental group received statistically significant higher scores in nominal, functional and multidimensional literacy dimensions than the control group in the posttest scores. The Cohen d values demonstrate that the difference refers to a practically large effect in the nominal (d = 0,97) and functional (d = 0,84) literacy dimensions and a medium level effect in the multidimensional literacy dimension (0,78) (Cohen, 1988).

3.2. Results on the second sub-problem

The descriptive analyses of the answers given by prospective teachers to open-ended questions are as follows. (see Table 6)

Table 6
Descriptive analysis of open-ended questions.

		N	1 point		2 points		3 points		4 points	
			n	%	n	%	n	%	n	%
1.week	Experimental Group	18	7	38,9	10	55,6	1	5,6	–	
	Control Group	16	–		15	93,8	1	6,3	–	
2. week	Experimental Group	23	4	17,4	8	34,8	10	43,5	1	4,3
	Control Group	19	5	26,3	10	52,6	4	21,1	–	
3. week	Experimental Group	26	3	11,5	7	26,9	12	46,2	4	15,4
	Control Group	22	–		19	86,4	1	4,5	2	9,1
4. week	Experimental Group	22	1	4,5	7	31,8	11	50	3	13,5
	Control Group	19	2	10,5	9	47,4	3	15,8	5	26,3
5. week	Experimental Group	20	1	5	7	35	10	50	2	10
	Control Group	18	2	11,1	2	11,1	8	44,4	6	33,3
6. week	Experimental Group	23	–		7	30,4	12	52.2	4	17,4
	Control Group	22	–		11	50	8	36,4	3	13,6

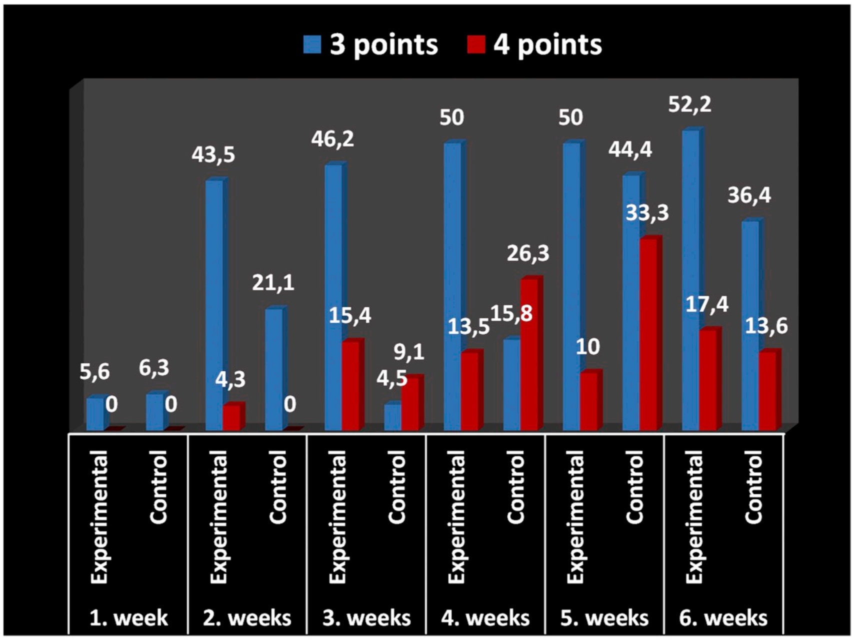

Fig. 1. Percentage of prospective teachers who score 3 and 4 from open-ended questions.

1 point: *When I buy yogurt, I usually follow my mother's advice. It usually comes from the village.*
2 points: *I check its consistency and water level. If it includes excess water, I do not buy it. If I have a chance to try it. I taste it because some of them can be sour.*
3 points: *If I can find village milk or yogurt, I buy it, because it contains no additives. It is therefore healthier. If I cannot find village yogurt, I buy the yogurt from the store by checking its brand and expiry date.*
4 points: *I check the numbers in the arrows behind the yogurt cup. I prefer the product with number 5. Because the yogurt with number 5 is harmless.*
1 point: *I do not check anything of the product; it is enough to be water. I get the bottle with a beautiful shape, so I like water more like this.*
2 points: *I check the product brand. I buy only recognized brands. Because they are both healthier and more reliable.*
3 points: *I take care that the pH of the water is about 7°. I also think the major brands are always healthier because they are always inspected.*
4 points: *I check the brand, coldness, and pH while buying water. As the human body is at certain pH ranges (7.35–7.45), I note that pH is at these levels.*

The percentage values of the prospective teachers who got the scores of 3 and 4 from the open-ended questions are presented in Fig. 1:

As seen in Fig. 1, there is an increase in the scores taken by the experimental group at all weeks, while there are fluctuations in the control group in the same period. For example; the percentage of prospective teachers in the control group that received three points increased in the second week and then decreased in the third week. The group then experienced an increase during the fourth and fifth week, and a decline in the sixth week.

4. Discussion and conclusion

This research was conducted to determine the effect of tools biotechnology instruction supported by Web 2.0 on biotechnology literacy of prospective science teachers. In the study, it was determined that the experimental and control groups had low biotechnology literacy levels before implementation. This result may be related to lack of knowledge of the prospective teachers. The studies in the literature state that people generally have inadequate knowledge of biotechnology (Doğru, 2010; Lamanauskas & Makarskaitė-Petkevičienė, 2008; Prokop, Lešková, Kubiatko, & Diran, 2007; Türkmen & Darçın, 2007). The lack of knowledge identified in studies may be associated with the nominal dimension of scientific literacy. Because an individual who lacks knowledge cannot reach higher levels of literacy. Therefore, we first need to address the lack of knowledge to increase biotechnology literacy.

It seems important for the prospective teachers to take biotechnology courses to eliminate the lack of knowledge (Bal, Keskin Samanci, & Bozkurt, 2007; Dawson & Soames, 2006). Erdoğan, Özsevgeç, and Özsevgeç (2014) concluded that biology and prospective science teachers who took courses on biotechnology and genetics during undergraduate education had scientific literacy higher than preschool and classroom prospective teachers did not take these courses. Therefore, biotechnology courses should be organized in a way that prospective teachers can improve their biotechnology literacy.

Due to the inadequacy of the biotechnology knowledge of prospective teachers, researchers have focused on conducting biotechnology education with different methods and techniques (Darçın, 2007; Reynolds & Hancock, 2010; Rothhaar, Pittendrigh, & Orvis, 2006). From the results of these studies, it can be concluded that using different methods and techniques in biotechnology is effective in eliminating the lack of knowledge. Eliminating the lack of knowledge is not enough for increasing biotechnology literacy. At the same time, it is necessary to establish links between this knowledge and associate them with daily life. Bybee's classification does not suggest a teaching sequence to improve literacy; this classification includes a vertical perspective as well as a horizontal perspective (Schwartz et al., 2006). For example; instead of teaching only concepts to improve the nominal dimension of the biotechnology literacy, the connections that will develop the upper dimensions should also be taught. Therefore, it is necessary to use methods, activities, and materials that can improve literacy in all dimensions in the teaching process. Thus this study focused on Web 2.0 tools used to improve biotechnology literacy. The results of the current research showed that Web 2.0 tools that provide different learning environments have contributed to biotechnology literacy in the biotechnology course. The results also indicated that in the dimension of multidimensional literacy, biotechnology literacy posttest scores of the prospective teachers in the experimental group were statistically significantly higher than their biotechnology literacy pretest scores, and also there was no statistically significant difference between biotechnology literacy pretest and posttest scores of the prospective teachers in the control group.

According to the results obtained from the research, biotechnology teaching supported by Web 2.0 technologies has improved biotechnology literacy in the dimensions of nominal, functional and multidimensional literacy. The reason for this contribution may be related to the collaborative, sharing, user-centered nature of Web 2.0 technologies. Dohn and Dohn (2017) have also stated that using Web 2.0 tools in educational activities provides rich opportunities for more collaborative and social learning environments. Churchill (2011) also asserted that when directed by a person, blogs have the potential to support teaching and learning activities effectively. However, O'Sullivan (2013) investigated the effect of wikis on the success in the selected concepts from the connection, physical variables, and chemical variables but found no significant differences in success in these three subjects.

The implementation in the research is also affected the decision-making process of the participants where the experimental group met in their daily lives. This can result from knowledge transmission through constant reminders via social networks and blogs. Sohan (1998) stated that biotechnology knowledge should be sufficient to be able to make decisions about biotechnology in the future. Prospective teachers in the experimental group were able to reflect their knowledge in their daily lives consistently. Also according to the results of Çiğdem (2012), which is aimed to determine the effect of blog keeping and daily note writing activities of prospective teachers on their reflective thinking levels in the teaching practice course, there are significant differences in favor of the experimental group between the posttest critical reflection scores of the experimental and control groups. However, there was no significant difference between habit, understanding and reflection scores of the experimental and control groups in post-tests.

In conclusion, the present study showed that biotechnology teaching supported by Web 2.0 tools has led to an increase in the biotechnology literacy of prospective science teachers, and also they used their biotechnology knowledge in the decision making process in their daily lives. They began to pay more attention to the brand of products they have already purchased and also checked their contents. This situation may be a sign of the improvement in the prospective teachers' biotechnology literacy. The fact that teaching supported by Web 2.0 technologies does not improve literacy at the procedural level may indicate the necessity of using different methods and techniques including interactive applications in teaching.

Moreover, the present study determined that as a result of teaching with Web 2.0 technologies, the prospective teachers in the experimental group had different biotechnology decisions compared to the control group. The study also concludes that Web 2.0 technologies are so intertwined with everyday life that prospective teachers integrate biotechnology into their everyday lives and when they make decisions accordingly. This situation can also be caused by integrating Web 2.0 technologies with the media. We can get any up-to-date developments and news via Web 2.0 technologies. Therefore, these technologies have become a part of our daily lives. Since biotechnology is also a media-related field, these technologies offer opportunities to the prospective teachers, who received Web 2.0 technology-assisted courses, to associate these technologies with their daily lives. This leads to an increase in biotechnology literacy. According to Sohan (1998), most students accept the media as the main source of biotechnology. Therefore, use these technologies for teaching biotechnology enables the prospective teachers to access biotechnology topics more easily in the research process, and also they are informed about current developments thanks to these tools. The study is limited to the level of the use of Web 2.0 tools by the prospective teachers. If teachers are allowed to use Web 2.0 tools in the pre-service period, they can make more use of these tools in their teaching process. Thus, this created the need for digital literacy for prospective teachers by changing the teaching process, including the use of Web 2.0 tools, implementing active methodologies, the acquisition, and development of competencies, and using innovative strategies (Garcia-Martin & Garcia-Sanchez, 2017). Thus teachers who are digital literate may be more willing to use these technology tools. Therefore, it is considered that if prospective teachers use Web 2.0 technologies in the teaching process in terms of biotechnology education, then they become familiar with these tools and integrate them into the teaching processes in their future classes. In this regard, it is necessary to integrate Web 2.0 technologies into teacher training programs to train biotechnology literate teachers.

Appendix. Examples of the questions of "Biotechnology Literacy Test."

Nominal literacy:

Which concept involves the definition of "the name given to the operation of reproducing the recombinant DNA molecules by inserting them to a suitable host cell"?

A) Transgenic Organism
B) Genetically Modified Organism
C) Gene Cloning
D) Fermentation
E) Recombinant Gene

Functional literacy:

Genetically modified *Escherichia coli* bacteria converted to sugar to a fuel which is very close to diesel oil. If the scope of this operation can be extended, it is thought that synthetic fuel may be an alternative to fossil fuel energy. Prof. John Love, who was within the team that carried out the research whose results were published on the "Proceedings of the National Academy of Sciences" magazine, commented as "we developed a redundant fossil fuel instead of substitution fuels such as biofuels. The purpose was the modification not to be realized by the car manufacturers, consumers, and fuel oil dealers."

What is the thing required to be described by the "genetically modified *Escherichia coli* bacteria" being referred in the above news?

A) Modifying the hereditary material of the bacteria
B) Modifying the cellular mechanism of the bacteria
C) Modifying the total protein number of the bacteria
D) Modifying the reproduction speed of the bacteria
E) Modifying the chromosomes of the bacteria

Procedural literacy:

A scientist wants to enable the production of tomato in cold weather. For this, s/he is considering to obtain gene from a type of fish living at the pole. Her/his hypothesis is that tomato can be grown in cold weather if the gene is obtained from a type of fish living at the pole and if it is transferred to tomato. How does the scientist test this hypothesis?

A) She/he observes the development of the tomato leaf obtaining gene from different species.
B) She/he measures the length of the tomato one day after each irrigation.
C) She/he measures the amount of water provided to plants in different areas.
D) She/he considers the number of seeds sown in each area.
E) Each day, she/he delivers different amounts of water to tomato.

Multi-dimensional literacy:

The scientists concluded that GMO (genetically modified organism) is harmful to human health as the result of their studies, and today the knowledge that the harm of GMO against human health is being discussed is included in science and technology books. In your opinion, can this knowledge change in the future?

A) This is scientific knowledge, and it never develops as it is a proven reality.
B) The scientists obtained this knowledge by doing many experiments; for this reason, this information is always correct; it does not change.
C) Scientific knowledge seems like it can change, but actually it does not; because new information is added to old knowledge and the old knowledge remains the same.
D) The old knowledge is interpreted again in the light of new inventions. Thus no knowledge is permanent.
E) The new knowledge replaces the old knowledge.

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